63-3-4

APRIL, 1963

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505 King Avenue
Columbus 1, Ohio

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Compiled by:

Patricia B. Plate

DEFENSE METALS INFORMATION CENTER

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Selected Accessions

April 1963

HIGH-STRENGTH ALLOYS

50675 MECHANICAL AND METALLURGICAL CAUSES OF FAILURE. H. Grover, Metals Engineering Quarterly, Vol. 3, No. 1, February, 1963, pp. 15-23
(6 references, 9 pages, 11 figures, 4 tables)

The author examines the use of the term "mechanical and metallurgical causes of failure" of engineering metals from three viewpoints: (1) on the basis of the theory of elasticity of a continuous body; (2) through consideration of the scale of observation and analysis; and (3) from the engineering point of view.

50704 THERMAL DIFFUSIVITY MEASUREMENTS ON METALS AND CERAMICS AT HIGH TEMPERATURES. R. L. Rudkin, W. J. Parker, and R. J. Jenkins, United States Naval Radiological Defense Laboratory, San Francisco, California. ASD TDR 62-24, Final Report, January, 1963, Contract No. MIPR 33(616)-61-7
(4 references, 20 pages, 10 figures)

The adaption of the NRDL flash method to the measurement of the thermal diffusivity of metals and ceramics at high temperatures is described. A high-intensity short-duration light pulse from a xenon flash lamp is absorbed in the front surface of a thermally insulated specimen a few millimeters thick and the resultant temperature history of the rear surface is measured by a lead-sulfide-cell radiation detector or a thermocouple, displayed on an oscilloscope, and photographed by a Polaroid Land camera. The thermal diffusivity of the material is determined from this temperature-versus-time curve provided the theoretical boundary conditions are experimentally satisfied. Measurements of the thermal diffusivity of Armco iron, molybdenum, titanium, zirconia, and alumina have been made up to 1200 C, 1300 C, 1700 C, 1100 C and 1100 C, respectively.

50774 BIAXIAL PROPERTIES OF METALS FOR AEROSPACE APPLICATIONS. C. W. Bert, Battelle Memorial Institute, Columbus, Ohio. AIAA Paper No. 2893-63 to be presented at the Launch and Space Vehicle Shell Structures Conference, AIAA, Palm Springs, California, April 1-3, 1963
(13 references, 25 pages, 7 figures, 3 tables)

50774 (Continued)

The following properties of thin metallic members under biaxial loading conditions are discussed: stress-strain curves, yield strength, and ultimate strength. Emphasis is placed on information useful in the design of primary structures of aerospace vehicles, liquid-propellant tankage, and solid-propellant motor cases. Three criteria for biaxial yield strength, comparable to the 0.2 per cent offset criterion for uniaxial yield strength, are discussed. Then a new generalized equation for describing the biaxial yield-strength envelope is presented. As an example, biaxial data for AISI 4340 steel heat treated to various strength levels are used.

50782 See Stainless Steels.

50818 STRAIN-RATE EFFECTS IN DEFORMATION PROCESSING. G. E. Dieter, E. I. du Pont de Nemours & Company, Wilmington, Delaware. Paper presented at the 9th Sagamore Ordnance Materials Research Conference, Syracuse University, Raquette Lake, New York. August 28-31, 1962
(85 references, 36 pages, 17 figures, 9 tables)

The literature on the strain-rate dependence of the mechanical properties of metals is reviewed with respect to how this applies to deformation processing where velocities of 20 to 3,000,000 inches per minute may be encountered. Strain rate has three effects in metal working. Increasing strain rate increases the basic resistance of the metal to deformation. Opposing this is the fact that at high deformation velocities the heat of deformation cannot be dissipated within the time of the event. The resulting temperature rise leads to a decrease in deformation resistance. High deformation velocities also alter the frictional conditions at the metal-tool interface, usually in the direction of improved lubrication so long as a film can be maintained. The new high-energy rate-forming techniques are described and discussed. The relative advantages and disadvantages of the pneumatic, electrical, and explosive methods are considered.

Cobalt Base

50812 See Stainless Steels.

Nickel Base

50614 See Engineering Steels.

50623 JOINING OF NICKEL-BASE ALLOYS. R. M. Evans, Battelle Memorial Institute, Columbus, Ohio. DOD, DMIC Report 181, December 20, 1962 (60 references, 72 pages, 18 figures, 35 tables)

The key to the success of many devices that are to be used in corrosive or high-temperature environments is often an ability to properly weld the nickel-base alloys. Alloys such as Monel, Inconel, etc., that do not depend upon relatively complex metallurgical reactions to obtain their desirable properties are not difficult to weld if proper procedures are used. Alloys which are relatively new (Rene' 41, Hastelloy R-235, Inconel X, etc.) and do depend on complex metallurgical reactions to develop their useful properties present many joining problems. This report covers, in a general way, the criteria for the successful fabrication of several alloys which fall in each category. Fusion welding, resistance welding, and brazing are covered. The welding of dissimilar nickel-base-alloy combinations and repair welding are also discussed.

50657 ENGINEERING PROPERTIES OF INCONEL ALLOY 600. The International Nickel Company, Inc., Huntington, West Virginia. Technical Bulletin T-7, (Received, March, 1963), (Trade Literature) (29 references, 34 pages, 18 figures, 45 tables)

The limiting chemical composition of Inconel nickel-chromium alloy 600 is shown in Table 2. Nickel contributes in high degree to its resistance to corrosion by many inorganic and organic compounds throughout wide ranges of acidity and alkalinity. Chromium confers ability to remain bright under exposure to sulfur compounds in the atmosphere or in other corrosives; it also provides resistance to oxidizing atmospheres at elevated temperatures, and to oxidizing conditions in corrosive solutions. Corrosion resistance, metallography, mechanical properties, and working instructions are the major headings considered.

50679 See Refractory Metals.

50683 See Stainless Steels.

50782 See Stainless Steels.

50795 See Composites.

50812 See Stainless Steels.

50842 See Titanium.

50851 PERFORMANCE OF ELECTRICAL-RESISTANCE STRAIN GAGES AT CRYOGENIC TEMPERATURES. A. Kaufman, National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. NASA TN D-1663, March, 1963 (3 references, 21 pages, 8 figures, 1 table)

50851 (Continued)

Six types of commercial foil strain gages were investigated for use at cryogenic temperatures. The performance characteristics that were studied were change in strain sensitivity, change in resistance, response to high strains, creep, zero drift, and hysteresis. The tests were conducted in liquid nitrogen and liquid hydrogen with a special strain-gage calibrator and at higher strains in liquid hydrogen with tensile specimens. Gages having Nichrome V or stabilized Armour D foil elements had characteristics most closely approximating those desired for temperatures down to 36 R.

Engineering Steels

50614 RESEARCH IN EXPLOSIVE WELDING (STUDIES OF VARIOUS METALS SYSTEMS). J. Pearson and G. A. Hayes, United States Naval Ordnance Test Station, China Lake, California. American Society of Tool & Manufacturing Engineers, Detroit, Michigan, paper No. SP63-97 presented at the Creative Manufacturing Seminars 1962-1963
(15 references, 26 pages, 29 figures, 6 tables)

During the last several years considerable interest has been generated in the use of high explosives for producing high-strength bonds between the surfaces of similar and dissimilar metals. The terms used to describe this type of operation include "explosive welding", "explosive cladding", "explosive joining", and "explosive bonding", with the first term being most extensively used. The wide variety of terms used to describe these operations seems to stem in part from the fact that in the metallurgical sense the exact nature of the metal joining process is still not completely understood, and that different metals systems appear to follow different behavior patterns depending on the properties of the metals to be joined and the parameters of the system.

Studies in these metals to date have been devoted mainly to understanding the mechanics of the process, determining the feasibility of welding various similar and dissimilar metals systems, and obtaining data on the microstructural and engineering properties of these systems. More recently, a few studies have been initiated in terms of commercial applications such as (1) cladding the surfaces of large flat plates, (2) lining the inner surfaces of long tubes and rocket nozzles, (3) joining billets of dissimilar metals prior to the rolling of bimetallic plates, and (4) various metal-explosive devices for performing unusual welding operations in shop, field, and remote locations. However, all such studies appear to be of a preliminary nature and the authors are not aware of any items in actual use at this time which have been prepared by explosive welding techniques.

50674 THE SIGNIFICANCE OF TENSILE, CREEP AND STRESS-RUPTURE DATA IN ENGINEERING DESIGN. P. M. Brister and M. N. Bressler, Metals Engineering Quarterly, Vol. 3, No. 1, February, 1963, pp. 7-14
(12 references, 7 pages, 12 figures, 1 table)

This paper discusses some mechanical properties of low-alloy steels, their significance, and how these properties have been used by metals engineers to establish design stresses which insure the structural adequacy of engineering designs in the boiler and pressure vessel field.

50766 FACTORS THAT DETERMINE THE APPLICABILITY OF HIGH STRENGTH QUENCHED AND TEMPERED STEELS TO SUBMARINE HULL CONSTRUCTION. W. S. Pellini and P. P. Puzak, United States Naval Research Laboratory, Washington, D. C. NRL, Report 5892, December 5, 1962
(4 references, 32 pages, 24 figures, 1 table)

An analysis is given of the potentials and limitations of high-strength, quenched-and-tempered steels for welded construction of submarine hulls.

50766 (Continued)

The explosion tear test is used to estimate the flaw-size-fracture-stress relationships. Correlations of these data with drop-weight tear-test data and Charpy-V-test data provide an indirect assessment of these relationships. These tests cover an extensive range of materials and strength levels.

50784 See Titanium.

50812 See Stainless Steels.

50815 CRACK TOUGHNESS OF TWO HIGH-STRENGTH SHEET STEELS. J. E. Srawley, T. C. Lupton, and W. S. Kenton, Sr., United States Naval Research Laboratory, Washington, D. C. NRL, Report 5895, February 13, 1963 (10 references, 11 pages, 3 figures, 5 tables)

Surface-cracked sheet specimens of a high-strength proprietary steel (AH) and a 0.52 per cent carbon modification of AMS 6434 steel (P-12) were heat treated to various yield strengths in the range 200,000 to 270,000 psi and tested to determine K_{Ic} plane-strain crack-toughness values. The K_{Ic} toughness of carbon-modified AMS 6434 was somewhat higher than that of AMS 6434 of normal carbon content at a yield strength of 225,000 psi. In the yield-strength range 220,000 to 243,000 psi, the K_{Ic} toughness of P-12 was considerably higher than that of AH. In addition to the results obtained at room temperature for both steels, tests on P-12 were also conducted at temperatures down to -295 F at two strength levels. Fracture-mode transitions from oblique to transverse occurred in this range of temperature, but these were not accompanied by abrupt changes in K_{Ic}.

50829 MICROSTRUCTURAL ALTERATIONS IN IRON AND STEEL DURING HOT WORKING. R. A. Grange, Paper presented at the 9th Sagamore Ordnance Materials Research Conference, Syracuse University, Raquette Lake, New York. August 28-31, 1962
(18 references, 17 pages, 19 figures)

Alterations in the austenite grain structure as a result of hot working are discussed. Austenite grains are deformed and subsequently recrystallized to new and usually smaller grains. Principal factors affecting kinetics of recrystallization and size of recrystallized grains are discussed. The deformation-induced recrystallization process can, by suitable control of the hot working process, develop a very fine-grained product. Over-all mechanical properties improve as the grain size is smaller.

Segregation and impurities in cast metal lead to a fiber structure in the hot-worked product. This results in poorer mechanical properties in the direction normal to that of principal deformation.

Modification of conventional hot-working technique so as to take full advantage of the grain-refining potential of austenite recrystallization can lead to improved hot-worked iron and steel products.

50842 See Titanium.

Stainless Steels

50614 See Engineering Steels.

50683 STEEL STRENGTH AND DUCTILITY RESPONSE TO ARC-WELDING THERMAL CYCLES. C. S. Williams, Welding Journal, Vol. 42, No. 1, January, 1963, pp. 1-s - 8-s
(5 references, 7 pages, 18 figures, 3 tables)

Increased performance requirements for materials and the need to use welding for fabrication have heightened interest in methods to assess the cracking potential of materials during welding. Such cracking is not always anticipated from conventional metallurgical evaluations. A novel approach to this problem was provided by the "Hot Ductility" test developed by Nippes and Savage. This report describes the performance of materials in a test similar to that of Nippes and Savage. The test is, however, modified by the use of higher maximum test temperatures and the provision of a new index of merit to indicate the relative susceptibility to cracking.

50685 NOTCH SENSITIVITY OF THE HEAT-AFFECTED ZONE IN TYPE 316 MATERIAL. R. J. Christoffel, Welding Journal, Vol. 42, No. 1, January, 1963, pp. 25-s - 28-s
(5 references, 4 pages, 4 figures, 4 tables)

A previous investigation indicated that the notch rupture strength of the heat-affected zone in Type 347 stainless steel weld joints in the as-welded condition was significantly lower than either the smooth or notch rupture strength of the unwelded base metal. This low notch rupture strength was considered to be a major factor contributing to the premature service cracking which has been encountered in Type 347 weld joints. Since Type 316 material is generally replacing Type 347 material for steam power piping applications, a similar study of the notch rupture properties of the heat-affected zone in Type 316 weld joints was conducted.

50720 A DISCUSSION OF THE FRACTURE TOUGHNESS OF SEVERAL STAINLESS STEELS IN SHEET FORM. F. J. Barone and A. M. Hall, Battelle Memorial Institute, DMIC, Columbus, Ohio. DMIC Memorandum 164, January 31, 1963, Contract No. AF 33(616)-7747
(13 references, 11 pages, 4 figures, 13 tables)

In view of the interest in stainless steels for skin materials in trisonic transports, and in view of the importance of fracture toughness as a factor in establishing the reliability of a material under high stress, it is the purpose of this report to discuss a number of stainless steels in terms of results which have been obtained from investigations concerned with their fracture toughness.

50782 ULTRA-FINE HIGH TEMPERATURE, HIGH STRENGTH METALLIC FIBERS. C. A. Gorton, C. C. McMahon, and J. A. Rizzardi, Hoskins Manufacturing Company, Detroit, Michigan. ASD TDR 62-727, Final Report, Part 1, August, 1962, Contract No. AF 33(616)-8366
(13 references, 70 pages, 49 figures, 3 tables)

50782 (Continued)

Eight superalloys of A-286, Elgiloy, Hastelloy B, M-252, Rene' 41, Udimet 500, Udimet 700, and Waspaloy were processed to ultra-fine fibers of approximately 0.001-inch diameter or less and evaluated for drawability. The room-temperature mechanical properties of the annealed fine fibers are presented. The effect of cold reduction on the mechanical properties is also included. The Elgiloy and Hastelloy B alloys processed more readily with less die wear than the remaining alloys.

The tensile strength at room temperature of each of the alloys, except A-286 was within the range of 160,000 to 220,000 psi as solution heat treated. Alloy A-286 tensile strength was approximately 100,000 psi. The alloys in order of decreasing strengths were U-700, Rene' 41, Hastelloy B, Waspaloy, U-500, M-252, Elgiloy, and A-286.

Multifilament yarns composed of 7, 19, and 37 filaments of Elgiloy and Rene' 41 were successfully processed to less than 0.003-inch diameter when sheathed with alloy Chromel-C, but the sheath could not be removed without damaging the fibers. High-temperature tensile tests of the sheathed yarn at 1600 F, 1800 F, and 2000 F in air and argon atmospheres indicated increased strength in order of increased number of filaments. The Chromel-C sheath protected the core fibers from oxidation and improved the high-temperature strength of the yarn at 1800 F and 2000 F.

50812 CUTTING TOOLS FOR MACHINING HIGH TEMPERATURE AND HIGH STRENGTH ALLOYS. W. R. Russell and R. G. Kennedy, The Cleveland Twist Drill Company, Cleveland, Ohio. American Society of Tool and Manufacturing Engineers, Detroit, Michigan. Technical Paper SP63-58 presented at the Creative Manufacturing Seminars 1962-63
(11 references, 16 pages, 18 figures, 2 tables)

Drill and end-mill life tests were run in an austenitic-stainless steel, A-286, a hot-work die steel, Thermold J, and two nickel-base high-temperature alloys, Udimet 700 and Waspaloy. End-mill-test end point was the measured wearland averaged for sixteen locations on the cutting teeth. For drill tests the thrust developed, the progress of the wearland at the corner of the drill point, and the usual gross-wear end point were studied. Gross-wear end point was generally used in reporting drill life.

Machine rigidity and end-mill construction were found to greatly influence tool life in the nickel-base materials where machining forces were developed which were over fifty per cent higher than forces encountered in end milling SAE 4340, Rc 50. Tool materials, including several high-hardness cobalt high-speed steels, exerted considerably less effect, from one grade to another, than did factors such as machine rigidity and end-mill construction.

Drill overhang, hole depth, and drill design were again found to exert a pronounced effect on drill life in the nickel-base alloys. High-speed steel grade influenced drill life moderately with one grade attaining predominance in the brief tests which were run.

50830 See Applications.

50842 See Titanium.

Iron Base

50625 See Titanium.

50719 REVIEW OF ALUMINUM-IRON MAGNETIC ALLOYS AND ASSOCIATED SYSTEMS (0 TO 10% ALUMINUM). H. H. Helms, Jr., United States Naval Ordnance Laboratory, White Oak, Maryland. NOLTR 62-144, January, 1963
(99 references, 86 pages, 22 figures, 12 tables)

Room-temperature magnetic properties of iron-aluminum alloys subjected to normal anneals and to "magnetic annealing" are reported as well as properties of materials exposed to temperatures up to 500 C and radiation environments of $\sim 10^{17}$ fast neutrons/cm^2. Oxidation resistance, magnetostriction, and special crystalline orientations are also discussed for these alloys.

50829 See Engineering Steels.

50842 See Titanium.

LIGHT METALS

50597 ANALYTICAL AND EXPERIMENTAL INVESTIGATIONS OF THE FRACTURE MECHANISMS OF CONTROLLED POLYPHASE ALLOYS. J. A. Ford and R. W. Hertzberg, United Aircraft Corporation Research Laboratories, East Hartford, Connecticut. Bureau of Naval Weapons, B-910068-1, Quarterly Progress Report No. 1, Contract No. N600(19)59361
(4 references, 26 pages, 12 figures, 1 table)

The results of preliminary investigations on selected unidirectionally-solidified-binary-eutectic alloys are reported in this quarterly progress report. These investigations have shown that the Cu-Cr and Al-Al_3Ni systems can be successfully unidirectionally solidified with only very occasional growth defects, bands, such that highly oriented microstructures result. Large ingots of the Al-$CuAl_2$ system have not been produced free of bands to date. However, several ingots with only slight or light bands have been obtained. The Al-Al_3Ni system has been chosen as an alternative for the Cr-$Cr_{23}C_6$ system, both rod-type eutectics, since the reinforcing rod or whisker in the latter system has been determined to be Cr rather than $Cr_{23}C_6$.

Mechanical testing of several unidirectionally-solidified Cu-Cr ingots, produced at fast growth rates, indicate that failure occurs by a combined shear and tensile mode. Similar experiments on as-cast and unidirectionally-solidified Al-Al_3Ni ingots which contain 11 volume per cent of a fibrous Al_3Ni phase indicate that controlled solidification has led to the production of a reinforced structure in which the load is successfully transferred to the fibers by the matrix. Several Cr whiskers, $< 1\mu$ diameter, have been tensile tested and have shown elastic strengths in excess of 1,000,000 psi and elastic moduli of 35 - 40,000,000 psi.

50611 FLOW AND FRACTURE PROBLEMS IN AEROSPACE VEHICLES. R. H. Kemp, Lewis Research Center, Cleveland, Ohio NASA, SP-27, December, 1962, paper presented at the NASA-University Conference on Science & Technology of Space Exploration, Chicago, Illinois, November 1-3, 1962
(5 references, 8 pages, 9 figures)

The problem of flow and fracture in high-strength space vehicle materials has been shown to be very complex. It was indicated in particular how the problem can be influenced by environmental factors such as cryogenic temperatures and extremely high impact velocities of meteoroids. Investigations range from the atomic to the macroscopic level. It is hoped that eventually, when sufficient knowledge has been acquired, it will be possible to merge the seemingly divergent approaches now being used into one basic concept that will enable the designer of a vehicle to arrive at a satisfactory design with an exceedingly high degree of reliability.

50612 See Composites.

50613 ENERGY CONSIDERATIONS IN EXPLOSIVE METAL WORKING (MEASURING THE ENERGY REQUIREMENTS FOR HERF AND THE EFFECTS OF HIGH ENERGY ON THE WORKPIECE PROPERTIES). J. Pearson, United States Naval Ordnance Test Station, China Lake, California. American Society of Tool & Manufacturing Engineers, Detroit, Michigan, paper No. SP63-26 presented at the Creative Manufacturing Seminars 1962-1963
(29 references, 29 pages, 17 figures, 8 tables)

In the explosive working of metals, large differences in the energy requirements and in the resulting behavior of the workpiece will occur depending on whether a standoff operation or a contact operation is performed.

In attempting to determine the energy requirements for an operation in either area, experience is still the primary guide. Although a large amount of basic information is available regarding certain phases of such operations there is still no single, simple method by which the inexperienced operator can readily determine the quantitative values of the system parameters required to satisfactorily perform a completely new operation. Several programs have been conducted to obtain general parametric design data, and considerable success has been achieved for a few specific types of operations, but even in these some empirical testing is required to establish dynamic behavior patterns.

The purpose of this paper is to review the basic type of information that is available, show how it is related to a specific problem, and indicate the types of information that are still required. Sources for expanded treatments of information are given. The discussion in this paper is restricted to the use of explosives as an energy source; however, much of the general information is readily related to other types of energy sources through appropriate conversion factors.

50704 See High Strength Alloys.

50819 THE FUNDAMENTAL ASPECTS OF FRACTURE IN DEFORMATION PROCESSING. H. C. Rogers, General Electric Company, Schenectady, New York. Paper presented at the 9th Sagamore Ordnance Materials Research Conference, Syracuse University, Raquette Lake, New York. August 28-31, 1962
(77 references, 58 pages, 39 figures, 1 table)

The aim of this report is to define the fundamental problem of fracturing itself, with its philosophic and semantic difficulties, to review some of the more critical experimental results which must be explained, to describe some of the major experimental difficulties which arise in attempting to assess the results and to try to give as accurate a current picture of fracturing as possible. The various deformation processes are reviewed and analyzed with respect to those variables which are of significance to the fracture process.

50831 FINISHING PROBLEMS ASSOCIATED WITH THE TITAN ICBM PROGRAM. L. E. Johnson and M. Piccone, The Martin Company, Denver, Colorado. Paper, (Received, March, 1963)
(7 pages)

50831 (Continued)

This paper presents some of the corrosion problems associated with the Titan program, together with the solutions to these problems. In particular, the development of a vinyl coating that is compatible with the Titan II propellants is discussed.

Beryllium

50612 See Composites.

50805 See Platinum Group.

50835 A STUDY TO DETERMINE THE DEFORMATION CHARACTERISTICS OF BERYLLIUM AND TUNGSTEN UNDER CONDITIONS OF HIGH HYDROSTATIC PRESSURE. Pressure Technology Corporation of America, Woodbridge, New Jersey. Bureau of Naval Weapons, Interim Report No. 1, February, 1963, Contract No. N 600 (19) 59430
(10 pages, 4 figures)

Specimens have been procured of tungsten for fluid-extrusion tests. Material has been received and orders placed for fluid-extrusion specimens of beryllium and for compression-test specimens, and tensile-test specimens of tungsten and beryllium.

Tensile-test and compressive-test fixtures were procured. The tensile-test fixture manifested some lack of uniform bearing of specimens on fixtures.

Preliminary fluid-extrusion tests were made on tungsten billets as a means of indicating the effect of pressure environment on deformation without fracture. It was found that crack-free deformation is possible provided sufficient pressure is available.

Titanium

50605 FRACTURE TOUGHNESS STUDY OF TI-6AL-6V-2SN TITANIUM ALLOY SHEET 0.1 INCH THICK FOR POSSIBLE APPLICATION IN THE CONSTRUCTION OF WELDED SOLID-PROPELLANT ROCKET MOTOR CASES. H. E. Romine, United States Naval Weapons Laboratory, Dahlgren, Virginia. NWL Report No. 1839, Technical Memo No. 223, February 4, 1963
(9 references, 11 pages, 25 figures, 6 tables)

K_c fracture-toughness tests were made on unwelded base metal heat treated to a range of yield strengths and on welded specimens simulating the girth welds in a rocket-motor casing. Machined starting notches were compared with fatigue cracks. The optimum strength-toughness relation for hoop stress in the cylinder wall occurred at a satisfactory value for σ_{YS}/ρ of about 1.0×10^6 inches. Fracture toughness was unsatisfactory in the welds because of a hard zone at the weld edge.

50612 See Composites.

50738 See Miscellaneous.

50761 DETERMINATION OF DESIGN DATA FOR HEAT TREATED TITANIUM ALLOY SHEET - VOLUME I. P. J. Hughest, Lockheed-Georgia Company, Marietta, Georgia. ASD TDR 62-335, Volume 1, Final Report, December, 1962, Contract No. AF 33(616)-6346
(4 references, 176 pages, numerous figures, numerous tables)

Mechanical and physical property data, necessary to fulfill the requirements of Phase II of the Department of Defense Titanium Alloy Sheet Rolling Program, were obtained for selected solution-treated-and-aged titanium alloys in sheet form.

Four alloys were investigated: B120VCA (Ti-13V-11Cr-3Al), Ti-6Al-4V, Ti-2.5Al-6V, and Ti-4Al-3Mo-1V. They were supplied by the producers in the heat-treated condition from three or more heats and three thicknesses of each alloy. Static mechanical-property data for tension, compression, bearing, shear, and crippling; creep and rupture data for tension, compression, bearing, and shear; and axial-load fatigue data were obtained at room and elevated temperatures. Fastener and weld-joint data from -320 F to 80 F and physical properties from -420 F to 1200 F were obtained.

Volume 1 summarizes mechanical and physical properties in a form consistent with those given in MIL-HDBK-5.

50768 LONG-TIME INTERMITTENT CREEP. O. N. Thompson and R. L. Jones, General Dynamics Corporation, Fort Worth, Texas. ASD, FPR-007, 2nd Quarterly Progress Report, January 15, 1963, Contract No. AF 33(657)-8907
(28 pages, 2 figures, 6 tables)

This program consists of measuring the effects of creep as well as the magnitude of creep resulting from steady and intermittent

50768 (Continued)

load application at 550 F and 650 F up to 30,000 hours. The materials under investigation are Ti8Al-1Mo-1V, Ti6Al-4V, AM350SCT, PH15-7Mo stainless steels, and Rene' 41 superalloy. This progress report describes the accomplishments to date in preparing for the test using multiple specimen testing on each creep machine.

50784 HIGH ENERGY RATE EXTRUSION PROGRAM. J. M. Rippel, Westinghouse Electric Corporation, Blairsville, Pennsylvania. ASD TR 7-882 (IX), Interim Technical Progress Report No. 9, Contract No. AF 33(600)-41948 (80 pages, 22 figures, 12 tables)

The feasibility of producing thin-section structural shapes suitable for aerospace application by the high-velocity extrusion technique has been demonstrated using a titanium alloy and steels.

During the current report period Phase II has been successfully completed by extruding Ti-6Al-4V titanium alloy, AISI 4340, and 304 stainless steel Tee sections 1-inch by 2-inches by 0.050-inch in lengths up to 10 feet. The titanium alloy extrusions in their entirety met all the requirements for straightness, surface finish, and dimensional control while the steel alloy extrusions contained local regions which were slightly undersize. A satisfactory straightening process was devised and extrusions of each material were shown to have satisfactory mechanical properties.

50803 DETERMINATION OF TITANIUM IN TITANIUM-ALUMINUM ALLOYS. R. Pribil and V. Vesely, Chemist-Analyst, Vol. 52, No. 2, April, 1963, pp. 43-44 (5 references, 2 pages, 2 tables)

A method for the determination of titanium in titanium-aluminum alloys containing iron in trace amounts is discussed. Where aluminum is present in amounts greater than a titanium to aluminum ratio of 1:50, titanium must be precipitated as the hydroxide, with triethanolamine masking of aluminum.

50805 See Platinum Group.

50838 DETERMINATION OF DESIGN DATA FOR HEAT TREATED TITANIUM ALLOY SHEET. W. M. McGee and B. R. Matthews, Lockheed-Georgia Company, Marietta, Georgia. ASD, ASD-TDR-62-335 Vol. 2a, Technical Documentary Report, December, 1962, Contract No. AF 33(616)-6346 (29 references, 413 pages, 359 figures, 88 tables)

Mechanical and physical property data, necessary to fulfill the requirements of Phase II of the Department of Defense Titanium Alloy Sheet Rolling Program, were obtained for selected solution-treated-and-aged titanium alloys in sheet form.

Four alloys were investigated: B120VCA (Ti-13V-11Cr-3Al), Ti-6Al-4V, Ti-2.5Al-16V, and Ti-4Al-3Mo-1V. They were supplied by the producers in the heat-treated condition from three or more heats and three thicknesses of each alloy. Static mechanical property data for tension, compression, bearing, shear, and crippling; creep and rupture data for tension, compression, bearing, and shear; and axial-load fatigue data were obtained at room and elevated temperatures. Fastener and weld joint data from -320 F to 80 F and physical properties from -420 F to 1200 F were obtained.

50842 INVESTIGATION OF THE METALLURGICAL ASPECTS OF SHEAR SPINNING. A. S. Rabensteine, Marquardt Corporation, Van Nuys, California. PR 281-3Q-3, March 1, 1963, Contract No. AF 33(657)-8706
(59 pages, 41 figures, 1 table)

An investigation was conducted to determine the shear-spinning characteristics of various materials used in the fabrication of ramjet engine components. The results of this investigation indicate that all of the materials which were tested lend themselves satisfactorily to the shear spinning process. The materials tested included the following: N-155, Inconel, Titanium A-70, 19-9DL, 2024 Aluminum, Titanium Allo-AT, 19-9DX, and HK31A Magnesium.

Magnesium

50842 See Titanium.

NONMETALLICS

50609 NONMETALLIC MATERIALS FOR SPACECRAFT. G. F. Pezdirtz, Langley Research Center, Langley Field, Virginia. NASA, SP-27, December, 1962, paper presented at the NASA-University Conference on Science & Technology of Space Exploration, Chicago, Illinois, November 1-3, 1962 (16 references, 10 pages, 19 figures)

Nonmetallic materials have many unusual and desirable properties for use in spacecraft applications, but their sensitivities to the ultraviolet and high-energy ionizing radiation of space have created problems—some as yet unsolved. The problems of thermal control coatings, polymers, and composites in space applications are discussed. The need for new nonmetallic materials with unusual properties such as inorganic polymers is also examined.

50620 See Applications.

50704 See High Strength Alloys.

Carbon, Graphite

50620 See Applications.

50738 See Miscellaneous.

50795 See Composites.

50802 See Special Refractories.

Special Refractories

50677 See Refractory Metals.

50706 CEMENTED TUNGSTEN CARBIDE WITH TITANIUM DIBORIDE ADDITIONS. M. E. Tyrrell and G. M. Farrior, United States Department of the Interior, Bureau of Mines, Washington, D. C. RI 6095, 1962 (12 pages, 5 figures, 7 tables)

The purpose of the work leading to this report was twofold: (1) To determine the properties of cemented tungsten carbide modified by the addition of one, two, and five per cent of titanium diboride, and (2) to compare the properties of these mixtures when sintered, hot-pressed, and flash-welded (resistance-sintered).

Minor additions of titanium diboride to mixtures of 94 per cent tungsten carbide and 6 per cent cobalt decrease mechanical strength but increase oxidation resistance in proportion to the amount of the addition. One per cent of titanium diboride increased the hardness by 2 Rockwell A units.

Hot-pressing produced compacts with the highest density and the best mechanical strength, but losses of cobalt were high and grain growth was pronounced.

50796 PYROFIBER, FREE-STANDING, PYROGRAPHITE AND PYROCARBIDE. Raytheon Company, Bedford, Massachusetts. Bureau of Naval Weapons, S-515, Final Report, Task III, Contract No. NOrd 19135 (FBM) (134 pages, 60 figures, 12 tables)

Process conditions have been determined for the manufacture of massive pieces as well as for the coatings of the various refractory pyrolytic carbides. Property measurements were made on the parameters bearing on missile applications for these materials. Pyrolytic graphite-carbide composites were found to have greater strength at elevated temperatures than any other known substance. Small-scale rocket nozzles have been fabricated and tested under conditions simulating an actual firing. The pyrolytic carbides show great promise for use in the most severe environments; however, further research is necessary to achieve their maximum potential.

50802 THE THERMAL PROPERTIES OF TWENTY-SIX SOLID MATERIALS TO 5000°F OR THEIR DESTRUCTION TEMPERATURES. Southern Research Institute, Birmingham, Alabama. ASD, ASD-TDR-62-765, Technical Documentary Report, January, 1963, Contract No. AF 33(616)-7319 (420 pages, 210 figures, 149 tables)

The thermal expansion, heat capacity, thermal conductivity, total normal emittance, electric resistivity, and thermoelectric voltage were investigated for 26 refractory materials, including the borides, carbides, nitrides, oxides, ATJ graphite, tungsten, and alloys of molybdenum and columbium. The temperature range was from 500 F to 5000 F. In addition to these thermophysical properties, the density, chemical analysis before and after temperature exposure, and microscopic pictures before and after temperature exposure are included to define the materials and assist in the analysis of the data.

50814 HEATS AND FREE ENERGIES OF FORMATION OF VANADIUM NITRIDE AND VANADIUM CARBIDE. A. D. Mah, United States Department of the Interior, Bureau of Mines, Washington, D. C. RI 6177, 1963
(14 references, 8 pages, 6 tables)

Energies of combustion of vanadium nitride (VN) and vanadium carbide (VC) were measured. Correcting to vanadium tetroxide (V_2O_4) as the final state, the heats of combustion were $\Delta H_{298.15}$=-118,700±100 cal/mole of vanadium nitride and $\Delta H_{298.15}$=-240,270±360 cal/mole of vanadium carbide. With vanadium pentoxide (V_2O_5) as the final state, the heats of combustion were $\Delta H_{298.15}$=-133,440±100 cal/mole of vanadium nitride and $\Delta H_{298.15}$=-255,020±360 cal/mole of vanadium carbide. Combining these results with vanadium oxide data, the heats of formation obtained were $\Delta H_{298.15}$=-51,880±200 cal/mole of vanadium nitride and $\Delta H_{298.15}$=-24,350±400 cal/mole of vanadium carbide. Heats and free energies of formation of vanadium nitride and carbide were calculated to 2,000 K.

50837 See Composites.

Ceramic Oxide

50677 See Refractory Metals.

50721 DISLOCATIONS AND THE TENSILE STRENGTH OF POLYCRYSTALLINE MAGNESIUM OXIDE. R. J. Stokes and C. H. Li, Honeywell Research Center, Hopkins, Minnesota. ONR, HR-63-252, Eighteenth Technical Report, January, 1963, Contract No. NR-032-451
(16 references, 21 pages, 3 figures, 2 tables)

The tensile strength of polycrystalline magnesia can be high (approximately 30,000 psi) providing there are no 'fresh' or mobile dislocations present. These dislocations may originate in one of two ways. In the first, they may be introduced directly by mechanical contact with the surface. In the second, they may be generated indirectly through the stress concentrations associated with pores. To attain tensile strengths higher than 10-15,000 psi it is necessary to use fully-dense pore-free material whose surface has been chemically polished or otherwise protected from mechanical contact.

50795 See Composites.

50802 See Special Refractories.

50848 HIGH TEMPERATURE, STEADY-STATE CREEP RATE IN SINGLE-CRYSTAL MGO. R. L. Cummerow, Union Carbide Corporation, Parma Research Laboratory, Parma, Ohio. Army Missile Command, RR No. C-13, Report, March 8, 1963, Contract No. DA 30-069-ORD-2787
(26 references, 27 pages, 4 figures, 2 tables)

Steady-state creep in single-crystal MgO in bending was measured in the temperature range 1450 C - 1700 C. The creep rate was measured as a function of temperature at constant load and at constant temperature. The possible influence of other experimental conditions was investigated.

50853 CERAMIC SYSTEMS FOR MISSILE STRUCTURAL APPLICATIONS. N. E. Poulos, S. R. Elkins, C. A. Murphy, and J. D. Walton, Georgia Institute of Technology, Atlanta, Georgia. Bureau of Naval Weapons, Quarterly Report No. 1, January 31, 1963, Contract No. NOw 63-0143-d
(36 pages, 10 figures, 6 tables)

The continued work involved the fabrication of slip-cast fused-silica radomes for rocket-sled rain-erosion evaluation and the establishment of surface flame-glazing parameters. New work initiated was directed towards improving the strength and thermal properties of slip-cast fused silica.

Major emphasis was placed on radome fabrication and arc-plasma flame glazing to have rain-erosion-test radomes ready for rocket-sled tests.

REFRACTORY METALS

50675 See High Strength Alloys.

50677 THE BEHAVIOR OF MATERIALS AT HIGH TEMPERATURES. C. D. Pears, Metals Engineering Quarterly, Vol. 3, No. 1, February, 1963, pp. 31-43 (13 pages, 17 figures, 1 table)

At temperatures above 3000 F, and up to 5500 F, the behavior of refractory materials requires that the engineer have a thorough understanding of many new concepts in addition to those traditionally related with design. Over this wide temperature range, the properties of the materials may change drastically so that average values cannot be used. Indeed, the design of the structure may require special consideration at the lower temperatures of, say, 2000 F, to permit performance until the higher temperature is obtained.

At the higher temperatures, the environmental conditions of pressure and chemistry have special significance. Also, the specific history of the material can influence the temperature-time relations and the metallurgical structure that can be influential in establishing the values of the properties. The old concepts, including tension modulus, thermal expansion, and emittances, require new definition and often must be treated as transient in time.

50679 SOME RECENT DEVELOPMENTS IN BRAZING. H. Schwartzbart, Metals Engineering Quarterly, Vol. 3, No. 1, February, 1963, pp. 52-63 (45 references, 12 pages, 21 figures)

The article discusses classification, terminology, and definitions in joining processes, with special reference to diffusion bonding for which a tentative definition is presented; the development of brazing filler alloys which contain temperature depressants which volatilize during the brazing operation; fiber-metal resistance welding or brazing and fiber-metal shim brazing; and the use of the electron-microprobe analyzer as a tool in brazing research.

50704 See High-Strength Alloys.

50774 See High-Strength Alloys.

50821 WORKING OF REFRACTORY METALS. W. Rostoker, Armour Research Foundation of Illinois Institute of Technology, Chicago, Illinois. Paper presented at the 9th Sagamore Ordnance Materials Research Conference, Syracuse University, Raquette Lake, New York. August 28-31, 1962 (14 pages, 2 figures)

Some of the unit processes are examined in terms of their purpose, operational factors, and relationships to preceding and subsequent processes.

50837 See Composites.

Columbium

50684 WELDING OF COLUMBIUM - 1% ZIRCONIUM. E. A. Franco-Ferreira and G. M. Slaughter, Welding Journal, Vol. 42, No. 1, January, 1963, pp. 18-s - 24-s
(9 references, 7 pages, 13 figures, 3 tables)

A study was conducted to investigate the aging behavior of welds in the Cb-1Zr alloy. This embrittlement, which appears to be that of the classical aging and overaging type, occurs in the temperature range 1500-1800 F. A special controlled-atmosphere chamber was constructed for making the welds, and a number of mechanical properties studies were made. Bend tests provided a ready means for qualitatively following the progress of aging, while tensile and hardness tests did not appear to be reliable indicators of change in ductility.

Postweld annealing in the range 1900-2200 F was found to result in overaging, and no embrittlement was noted after subsequent heating at lower temperatures. Metallographic examination was found to provide a good correlation between annealing time and temperature and the amount of precipitate which was present.

Welds with high oxygen-impurity levels may also be prevented from aging by the proper annealing treatment, but microcracking is apt to occur when welding highly contaminated material.

50707 See Molybdenum.

50791 See Vanadium.

50802 See Special Refractories.

50805 See Platinum Group.

Chromium

50597 See Light Metals.

Molybdenum

50614 See Engineering Steels.

50707 WELDING OF REFRACTORY METALS. D. J. Seman, Universal-Cyclops Steel Corporation, Bridgeville, Pennsylvania. Bureau of Naval Weapons, Interim Report No. 1, January, 1963, Contract No. NOw 63-0043-c (4 pages)

This program will evaluate the welding variables for refractory metals using production welding equipment. With this knowledge it is desired to establish production equipment specifications.

To accomplish the objectives of the program, the InFab facility will be used to the fullest extent.

The literature and industrial survey has been initiated and questionnaires have been prepared. A master mailing list has been compiled and is being checked for omissions.

Equipment for the welding program has been purchased. Initial studies will begin with another apparatus now being assembled.

50717 EVALUATION OF MOLYBDENUM METAL PRODUCED BY THE TIN REDUCTION OF MOLYBDENUM DISULPHIDE PROCESS. C. Krey, Oregon Metallurgical Corporation, Albany, Oregon. Bureau of Naval Weapons, Quarterly Report No. 3, Contract No. NOw 62-0754-c (7 pages)

A total of 160 pounds of molybdenum was produced by the tin-reduction process. One experimental molybdenum ingot Mo-1 was final melted and sectioned for testing. Tensile test and bend test specimens were made from as-cast material.

A second experimental ingot was first melted, and a molybdenum ingot produced from commercial molybdenum powder was first melted.

Carbon in high concentrations in molybdenite was found hard to remove completely. Extensive processing of MoS_2 with wet hydrogen continues with particular attention focused on obtaining good random samples of processed material for analyses.

The "Molybdenum Blue" material isolated from previous molybdenite leaching with acetone was amorphous and thus not amenable to X-ray diffraction identification. Since only a small amount of material was isolated, further identification work was impossible.

50769 MECHANICAL AND PHYSICAL PROPERTIES OF TZM MOLYBDENUM ALLOY SHEET AND OF TUNGSTEN SHEET. C. L. Dotson, Southern Research Institute, Birmingham, Alabama. Bureau of Naval Weapons, 5789-1479I, 1st Quarterly Progress Report, March 4, 1963, Contract No. N600(19)-59530 (9 pages, 1 table)

The sheet materials will be supplied in the optimum condition (warm-worked and stress-relieved) developed in Phase I of the BuWeps Refractory Metals Sheet Program. In addition to this condition, specimens will also be evaluated in two other conditions: coated and recrystallized. As part of the required experimental work, recrystallization temperatures will be pre-determined and will then be used in treating the as-received sheet materials to obtain the necessary recrystallized

50769 (Continued)

specimens. For the evaluation of coated specimens, we will provide for the application of coatings to sheet specimens prepared from the as-received material. The selection of the coatings for the molybdenum alloy and tungsten will be made in collaboration with personnel at BuWeps.

50771 MOLYBDENUM SHEET ROLLING PROGRAM. W. A. McNeish, Universal-Cyclops Steel Corporation, Bridgeville, Pennsylvania. Navy Bureau of Aeronautics, Interim Report No. 19, January 25, 1963, Contract No. NOas 59-6142-c (36 pages, 12 figures, 7 tables)

With resumption of InFab operation sheet bars were hot forged for Mo-0.5Ti Phase III production of 0.060-inch sheet. TZM sheet bars required for Phase II rolling-variable evaluation were also forged. During this period the rolling of both materials was completed and evaluation approximately 90 per cent completed.

An extension of this contract is presently required to permit completion of Mo-0.5Ti production and initiation of work on the production of TZM (Phase III).

Equipment is presently being installed in InFab. Resumption of operation is scheduled for late February.

50778 DEVELOPMENT AND PRODUCTION OF IMPROVED MOLYBDENUM SHEET BY POWDER METALLURGY TECHNIQUES. R. B. Bargainnier, R. F. Cheney, and L. D. Tiala, Sylvania Electric Products Inc., Towanda, Pennsylvania. Bureau of Naval Weapons, Final Report, January 31, 1963, Contract No. NOas 60-6018-c (10 references, 68 pages, 19 figures, 16 tables)

A powder-metallurgical molybdenum alloy was developed which, in wrought form, has properties as good as or better than those of arc-cast Mo-0.5Ti. The alloy, Mo-0.5Ti-0.03C (MTC), was selected after screening 15 molybdenum-alloy systems.

Process specifications for 40-mil MTC sheet were developed. In the as-rolled condition the sheet has an ultimate tensile strength at 1200 C of about 60 ksi. It is approximately 50 per cent recrystallized after one hour at 1210 C, and its ductile-brittle transition temperature is below room temperature.

MTC seems to be responsive to strain-induced precipitation strengthening in a manner similar to that ascribed by other investigators to certain arc-cast molybdenum alloys. Sintering at $\geq$ 1850 C is necessary to develop the best properties in MTC sheet.

50802 See Special Refractories.

50805 See Platinum Group.

Tantalum

50614 See Engineering Steels.

50707 See Molybdenum.

50794 PILOT PRODUCTION AND EVALUATION OF TANTALUM ALLOY SHEET. R. L. Ammon and R. T. Begley, Westinghouse Electric Corporation, Astronuclear Laboratory, Pittsburgh, Pennsylvania. Bureau of Naval Weapons, WANL-PR-M-003, Quarterly No. 3, February 16, 1963, Contract No. NOw-62-0656-d (7 references, 25 pages, 5 figures, 10 tables)

This report presents information regarding the correlation of hot hardness with tensile properties of T-111 (Ta-8W-2Hf). Thermal-expansion and electrical-resistivity data are also included. Evaluation of the effects of interstitial additions on the properties of the T-111 base composition was initiated. Preliminary results indicate that moderate concentrations of carbon, oxygen, and nitrogen have no detrimental effect on fabricability or weldability, and appear to benefit tensile properties at all temperatures. Stress-rupture properties for Ta-W-Hf alloys containing 14 weight per cent total solute concentrations are given. Tensile properties and weld-bend ductility for a Ta-11.2W-2.8Hf alloy are also presented. This alloy displays a 2T bend-transition temperature well below room temperature. Work on other Ta-base alloys is also described.

50805 See Platinum Group.

Vanadium

50663 VANADIUM ALLOYS. R. J. Van Thyne, Space/Aeronautics, Vol. 39, No. 2, February, 1963, pp. 91-93
(3 pages, 2 figures, 3 tables)

Offering a favorable combination of strength, density, ductility, and workability, vanadium is about to join the family of high-temperature metals for aerospace applications. This article compares the performance of vanadium-columbium systems with that of other refractory-metal alloys, and reviews the fabricability and weldability of the new alloys. In covering oxidation protection, it also points out that the formation of molten vanadium pentoxide, once considered a drawback, actually may be what makes vanadium alloys oxidation-resistant.

50791 DISPERSION-STRENGTHENED VANADIUM ALLOYS. F. C. Holtz, Armour Research Foundation, Illinois Institute of Technology, Chicago, Illinois. Bureau of Naval Weapons, ARF-B6007-1, Bimonthly Report No. 1, March 12, 1963, Contract No. N600(19)59567
(13 pages, 2 tables)

Dispersion-strengthening mechanisms are under investigation in alloys based on the vanadium-columbium system for the purpose of improving stress-rupture properties. Ten compositions containing small carbon additions in combination with hafnium or zirconium have been prepared by nonconsumable-electrode arc melting. Powder metallurgy preparation of alloys containing dispersed refractory particles is also under investigation. Minus 325 mesh powders of a V-Cb-Ti alloy were produced by the hydride process; the sintered compacts were over 90 per cent of theoretical density and possessed a relatively high degree of compressive ductility at room temperature.

50805 See Platinum Group.

50813 ANALYSIS OF HIGH-PURITY VANADIUM BY OPTICAL EMISSION SPECTROGRAPHY. L. Carpenter and K. Hazen, United States Department of the Interior, Bureau of Mines, Washington, D. C. RI 6182, 1963
(16 references, 16 pages, 4 figures, 6 tables)

Eighteen elements were determined spectrochemically in vanadium metal and its compounds in the general range of 1 to 1,000 ppm by means of spark-ignited unidirectional arc excitation. The samples were converted to vanadium pentoxide and combined with a mixture of graphite, lithium carbonate, and gallium oxide. For the molybdenum determination, the oxidized samples were mixed with sodium chloride and packed in copper electrodes. Average precision of the method was 15.6 per cent relative standard deviation, and relative error was 4.4 per cent.

Tungsten

50620 See Applications.

50707 See Molybdenum.

50769 See Molybdenum.

50802 See Special Refractories.

50835 See Beryllium.

Platinum Group

50619 RECENT DEVELOPMENTS IN THE APPLICATION AND ELECTROPLATING OF RHENIUM. E. K. Camp, American Chemical and Refining Company, Waterbury, Connecticut. Paper presented at the 2nd National Aerospace Finishing Symposium, Kansas City, Missouri, January 18, 1963
(16 references, 6 pages)

Rhenium's conductive-oxide, high-work function, and high-melting point make it particularly useful in space environments for heat-shields, catalysts, electric-arc-discharge points, slip rings, electrical contacts, diffusion barriers and emmitters. Explorations with a slightly acid-complexed phosphate bath have yielded improved corrosion resistant deposits. Microhardnesses (VHN 20g) as low as 300 and as high as 800 kg/mm^2 have been obtained.

50805 DETECTION AND ANALYSIS OF RARE ELEMENTS. A. P. Vinogradov and D. I. Ryabchikov, National Science Foundation, Washington, D. C. Translated by the Israel Program for Scientific Translations, Jerusalem, 1962
(744 pages)

This handbook is published as a manual for the analysis of rare elements. It describes methods tested in the analytical laboratories of research institutes and factories.

In the preparation of this handbook wide use was made of the work of Soviet analytical chemists, which includes papers published heretofore for internal departmental use only.

The data are arranged in chapters dealing with the elements in accordance with their position in the periodic system. Each element (or group of elements) has been reviewed on the basis of the latest knowledge on its analytical chemistry. The treatment is derived from the experience of Soviet and foreign scientists, and each chapter contains a critical discussion of the available methods, and an extensive bibliography of recent publications.

Each chapter describes the two or three most suitable physical, physico-chemical, and chemical methods for the analysis of raw materials, products in the course of manufacture, and pure metals.

MISCELLANEOUS

50610 ABLATION MATERIALS FOR ATMOSPHERIC ENTRY. L. Roberts, Langley Research Center, Langley Field, Virginia. NASA, SP-27, December, 1962, paper presented at the NASA-University Conference on Science & Technology of Space Exploration, Chicago, Illinois, November 1-3, 1962
(30 references, 8 pages, 7 figures)

Some of the more important concepts of thermal protection by ablation are described and the extent of progress in ablation materials research is discussed.

A short summary of the thermal environment is given, followed by a discussion of the several ablation processes with particular emphasis on charring ablation. The problem of environment simulation is then discussed and examples of typical facilities presented. Finally, some of the materials that have been successfully flight tested are reviewed.

50637 See Applications.

50705 PREPARATION AND CHARACTERIZATION OF HIGH-PURITY SINGLE-CRYSTAL BORON. I. R. King, G. R. Taylor, Jr., F. E. Wawner, Jr., and C. P. Talley, Texaco Experiment Incorporated, Richmond, Virginia. ASD TDR 62-427, Final Report, January, 1963, Contract No. AF 33(616)-7884
(9 references, 41 pages, 13 figures, 5 tables)

Crystalline boron specimens about 3 to 4 millimeters in diameter and several centimeters in length were prepared by chemical vapor plating and subsequently floating-zone melted. X-ray-diffraction studies showed them to be the β -rhombohedral phase and single crystalline over most of the zone-melted portions. Electrical and optical measurements were made on some of the boron single crystals produced.

50734 See Composites.

50738 PROCEEDINGS OF THE 4TH NATIONAL SAMPE SYMPOSIUM - MATERIALS COMPATIBILITY AND CONTAMINATION CONTROL PROCESSES. Society of Aerospace Material and Process Engineers, Hollywood, California. November 13-15, 1962

Eighteen papers were presented at the SAMPE Symposium. Among the subjects discussed were: microbiological contamination, filament-wound structures, adhesive bonding, brazing graphite, radioactive decontamination, chemical cleaning, reactivity of titanium with oxygen, and nonreactive greases.

50760 EXPLOSION WELDING. V. S. Sedykh, A. A. Deribas, Ye. I. Bichenkov, and Yu. A. Trishin, National Aeronautics and Space Administration, Washington, D. C. TT F-140, Technical Translation, March, 1963
(9 references, 12 pages, 9 figures, 1 table)

The possibility of welding metals of the same and different types, and also of obtaining welded joints of large area, by means of an explosion has been experimentally established. The experiments show that the types of explosives used are of major importance, the most suitable for this purpose being low-density explosives in granular form.

50763 DEVELOPMENT OF NON-VACUUM ELECTRON BEAM WELDING. L. H. Leonard, Alloyd Electronics Corporation, Cambridge, Massachusetts. ASD, AFSC TR 7-926(III), Interim Technical Engineering Report, January, 1963, Contract No. AF 33(657)-7237
(1 reference, 10 pages, 1 figure, 3 tables)

Electron-beam welding of aero-space metals in a non-vacuum environment is feasible if the electron beam has sufficient initial power density that after being degraded by scattering, the residual power density is adequate to accomplish joining. This report discusses the operational difficulties with a system fabricated to accomplish such welding.

50795 See Composites.

50797 REVIEW OF USES FOR DEPLETED URANIUM AND NONENERGY USES FOR NATURAL URANIUM. M. S. Farkas, Battelle Memorial Institute, Columbus, Ohio. DMIC Memorandum 165, February 1, 1963
(20 references, 21 pages, 2 tables)

This memorandum mentions the applications and investigations of depleted and natural uranium being pursued in the United States and Canada. The following topics are presented: (1) Past Nonenergy Consumption of Uranium, (2) Properties of Uranium and Uranium Alloys, (3) Nuclear Uses for Depleted Uranium, (4) Shielding, and (5) Uses for Depleted Uranium in the United States and Canada.

50806 ELECTRON BEAM TECHNOLOGY. R. Bakish, Electronics and Alloys, Inc., Ridgefield, New Jersey. Book, 1962
(numerous references, 452 pages, numerous figures, numerous tables)

This book aims to give the basic facts and ideas which made Electron Beam Technology possible. It attempts to show why electron beams have become a prime mover and a common denominator to this technology. It also attempts, by discussing the areas where beams are applied, to state the boundaries of this technology.

50822 METHODS OF SOLUTION OF METAL FORMING PROBLEMS. S. Kobayashi and E. G. Thomsen, University of California, Berkeley, California. June, 1962, paper presented at the 9th Sagamore Ordnance Materials Research Conference, Syracuse University, Raquette Lake, New York. August 28-31, 1962
(27 references, 27 pages, 14 figures)

The methods, both theoretical and experimental, which are available for the analysis of metal forming problems, are discussed and the mathematical meanings of the solutions are clarified. The slab method, which is based on a simplified state of stress, is applicable with good approximation to some forming problems. The uniform deformation-energy method is a simple means for obtaining the average forming stresses. For perfectly plastic-rigid materials the upper bound method, an application of the limit-load theorems to plastic deformation processes, offers a wide application to various forming processes, while the slip-line method has been used extensively in solving problems under plane strain conditions. Examples of sheet drawing and compression of a slab

50822 (Continued)

are given as illustration of the foregoing methods. In addition, visioplasticity, a semi-experimental method, provides a technique for finding stress distributions from experimentally obtained strain-rate distributions in forming problems, and its usefulness is demonstrated in extruding a cylindrical billet through square dies.

50825 SURFACE CONDITIONS IN DEFORMATION PROCESSES. M. C. Shaw, Carnegie Institute of Technology, Pittsburgh, Pennsylvania. Paper presented at the 9th Sagamore Ordnance Materials Research Conference, Syracuse University, Raquette Lake, New York. August 28-31, 1962
(19 references, 20 pages, 16 figures)

One or more die faces are employed in most practical deformation processes. Where plastic deformation is essentially normal to the die fact (Brinell hardness test) friction plays a negligible role. In most plastic flow processes, however, there is a shear complement of deformation and friction plays a major role. The friction associated with a die face differs significantly from that for lightly loaded sliders.

In certain plastic flow processes it is possible to arrange hydrodynamic support at the die face. This will normally result in less die wear, but poorer finish if the viscosity of the hydrodynamic medium is such as to provide low friction. Other methods of controlling the magnitude of the friction on a die face include boundary lubrication, contaminated microcracks, a steep temperature gradient near the surface and vibration of the surface.

The utility of plasticine as an analog modelling material in plastic flow studies is illustrated by some of the figures presented.

50849 FREQUENCY BANDWIDTH CONSIDERATIONS IN ULTRASONIC TESTING. C. P. Merhib, Watertown Arsenal Laboratory, Watertown, Massachusetts. WAL TR 143.7/1, Technical Report, January, 1963
(5 references, 13 pages, 5 figures, 2 tables)

The determination of flaw geometry and flaw orientation is a complex and difficult problem whose solution has been sought since the beginning of ultrasonic testing. Significant advances have been made toward solution of this problem, but many details have yet to be resolved.

The frequency bandwidth effects in relation to the above problem and the influence of bandwidth on amplitude indications from test blocks commonly used to calibrate equipment sensitivity are discussed. In addition, an outgrowth of the above work is a realization of the necessity for periodic evaluation of transducers.

Coatings

50852 A DYNAMIC THERMAL VACUUM TECHNIQUE FOR MEASURING THE SOLAR ABSORPTANCE AND THERMAL EMITTANCE OF SPACECRAFT COATINGS. W. B. Fussell, J. J. Triolo, and J. H. Henninger, National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland. NASA TN D-1716, March, 1963
(9 references, 27 pages, 8 figures, 1 table)

The various optical and thermal methods of measuring solar absorptance and thermal emittance are first discussed in some detail. Then the thermal-vacuum technique is described. The apparatus consists of: (1) a high-vacuum chamber with inner walls cooled by liquid nitrogen, and (2) a powerful carbon arc lamp.

50853 See Ceramic Oxides.

50605 See Titanium.

50609 See Nonmetallics.

50620 EROSION RESISTANCE AND FAILURE MECHANISMS OF SEVERAL NOZZLE MATERIALS IN A SMALL SOLID-PROPELLANT ROCKET ENGINE. R. A. Signorelli and J. R. Johnston, Lewis Research Center, Cleveland, Ohio. NASA TN D-1658, Technical Note, February, 1963
(16 references, 48 pages, 9 figures, 2 tables)

A small-scale end-burning solid-propellant rocket-engine facility was constructed, and an investigation was conducted to study uncooled rocket-nozzle insert materials under carefully controlled test conditions. Relative performance and metallurgical failure mechanisms were determined for 12 nozzle materials, including refractory metals, graphites, cermets, reinforced plastics, and a ceramic. A nonaluminized propellant, Arcite 368, which has a theoretical flame temperature of 4700 F was used. The engine was designed to operate at a chamber pressure of 1000 pounds per square inch for 30 seconds with a nozzle-throat diameter of 0.289 inch.

With the exception of molybdenum, all of the materials eroded to some degree. In general, the cermet and ceramic materials eroded very little (1 to 2 mils), tungsten and ZT graphite eroded moderately (5 to 9.5 mils), and the molded graphites and the 40-per-cent-resin phenolic-refrasil-composite material eroded extensively (up to 30.5 mils). The 20-per-cent-resin phenolic-refrasil and the phenolic-graphite materials eroded drastically (up to 54 mils), while complete failure occurred with phenolic-nylon material. The cermet and ceramic nozzles cracked extensively both radially and axially as a result of thermal stresses. Oxidation is believed to be the primary mechanism by which material was removed from the tungsten nozzle. Material removal from the graphite nozzles is attributed to oxidation coupled with mechanical erosion. Temperature measurements made with molybdenum and graphite nozzles indicated that the maximum throat-surface temperatures were slightly less than 3000 F, which is considerably below the 4700 F flame temperature.

A technique for propellant burning-surface modification was developed involving internal ballistic formulas, which permits the systematic variation of engine chamber pressure.

50637 EXPANDABLE SPACE STRUCTURE. P. M. Knox, Jr., A. Corell, and E. Lane, Martin Company, Denver, Colorado. ASD TDR 7-943a(1), Interim Technical Documentary, Contract No. AF 33(657)-9733
(numerous pages, numerous figures, numerous tables)

Tests completed to determine feasibility of deployment and stowage are discussed. These include the following operational mock-ups: (1) Full-scale structure with single ply bladder, and (2) $\frac{1}{4}$-scale structure with double-ply bladder to simulate self-sealing.

Results of eight meteoroid puncture tests in representative panels are presented and data are analyzed.

The materials test program is defined. Results of thermal properties tests on fibrous insulations are described.

Manufacturing tests, tooling studies, value engineering activities and weight studies are discussed.

The plans for the remainder of Phase I, which include release

50637 (Continued)

of engineering drawings, operable mock-up tests, environmental analyses and tests, manufacturing tests, tooling studies, and materials tests are presented.

50726 PERFORMANCE AND SOME DESIGN ASPECTS OF THE FOUR-STAGE SOLID-PROPELLANT ROCKET VEHICLE USED IN THE RAM A1 FLIGHT TEST. J. Levine, Langley Research Center, Hampton, Virginia. NASA TN D-1611, March, 1963 (10 references, 49 pages, 19 figures)

A general description, some details of mechanical design and construction, and performance (including angle of attack of the rolling last stage) of a four-stage solid-propellant rocket system used in the RAM (Radio Attenuation Measurement) A1 flight test are presented. The fourth stage attained a maximum velocity of 17,800 feet per second at an altitude of 175,000 feet. Temperature data on the nose cone are also discussed.

50738 See Miscellaneous.

50761 See Titanium.

50766 See Engineering Steels.

50796 See Special Refractories.

50801 See Stainless Steels.

50824 ULTRA-THIN SECTIONS. N. H. Polakowski, Illinois Institute of Technology, Chicago, Illinois. Paper presented at the 9th Sagamore Ordnance Materials Research Conference, Syracuse University, Raquette Lake, New York. August 28-31, 1962 (16 references, 19 pages, 9 figures)

Basic problems associated with the manufacture of wire, flat products and tubing in very thin sections are briefly discussed and the largely economical limitations of the first item are contrasted with the preponderantly technical difficulties of the others.

The question of flatness of sheet and strip is discussed next. Both old and new, potentially effective devices for continuous camber adjustment as well as leveling methods are considered.

Attention is drawn to the unique problems associated with the production of large, thin sheets from metals of limited availability when material cost is high while ingot size is small. The feasibility of a drastic increase of lateral dimensions of sheet beyond those imposed by the width of existing rolling mills is pointed out and demonstrated on small-scale experiments involving drawing of a sheet wrapped in a tight scroll.

50830 AN EVALUATION OF SIX MANUFACTURING METHODS OF A-286 12 POINT BOLTS FOR THE E-25 COMMITTEE. G. W. Gries, Standard Pressed Steel, Jenkintown, Pennsylvania. Report No. 956, February 25, 1963 (2 pages, numerous figures, 6 tables)

50830 (Continued)

PURPOSE: Data obtained in the A-286 fastener program requested by the E-25 Committee of the SAE are presented.

50851 See Nickel Base.

50853 See Ceramic Oxide.

Composites

50594 MECHANICAL BEHAVIOR OF INTERMETALLIC COMPOUNDS. P. Stark, J. Ryan, and S. V. Radcliffe, ManLabs, Inc., Cambridge, Massachusetts. ASD, ASD-TDR-62-1087, Technical Documentary Report, January, 1963, Contract No. AF 33(657)-7432
(52 references, 82 pages, 33 figures, 13 tables)

Suitable melting, casting, and fabrication techniques have been developed for the preparation of the intermetallic compounds VNi_3 and VCo_3 in a form suitable for the study of mechanical behavior. The annealing behavior of arc-melted, rolled, and extruded materials has been examined using metallographic and hardness techniques. The mechanical behavior of cast and extruded material of various grain size and degrees of order has been determined by indentation stress-strain, compression and tensile testing, and fractography. Arc-melted ingots of VNi_2, V_2Ni, V_3Ni, VCo, and V_3Co have been prepared and the feasibility of their homogenization and fabrication examined. An extensive review of the relevant literature has been completed. Finally, the validity of a method of computing Young's modulus for intermetallic compounds has been investigated.

50612 HIGH-STRENGTH MATERIALS RESEARCH. H. B. Probst, Lewis Research Center, Cleveland, Ohio. NASA, SP-27, December, 1962, paper presented at the NASA-University Conference on Science & Technology of Space Exploration, Chicago, Illinois, November 1-3, 1962
(16 references, 8 pages, 16 figures)

Some of the research that is in progress at the Lewis Research Center and that is devoted to improved strength characteristics of materials is reviewed. The review is made according to temperature ranges and covers many areas of vastly different materials and applications. The common thread in all these programs is improved strength.

50678 DEVELOPMENT OF HIGH-STRENGTH, HEAT-RESISTANT ALLOYS BY WHISKER REINFORCEMENT. W. H. Sutton and J. Chorne, Metals Engineering Quarterly, Vol. 3, No. 1, February, 1963, pp. 44-51
(24 references, 8 pages, 7 figures, 2 tables)

The use of high-strength, single-crystal fibers, or "whiskers", as structural reinforcement, offers a means for greatly increasing the strength of metals and alloys at elevated temperatures.

This paper discusses the concept of whisker reinforcement, and presents experimental data which indicate that such reinforcement is feasible at elevated temperatures. Experimental studies were conducted on the tensile behavior of silver-Al_2O_3 (whisker) composites which were used as a model system; one composite exhibited a tensile strength of nearly 45,000 psi at 1400 F, which is more than 20 times that of the pure silver. The problems involved in the achievement of high-strength composites are discussed and comparisons are made with other methods used to strengthen metals at elevated temperatures.

50724 PROCESS AND DESIGN DATA ON A BORIDE-SILICIDE COMPOSITION RESISTANT TO OXIDATION TO 2000 C. I. M. Logan and J. E. Niesse, The Carborundum Company, Niagara Falls, New York. ASD, ASD-TDR-62-1055, Technical Documentary Report, November, 1962, Contract No. AF 33(616)-8041 (16 references, 144 pages, 69 figures, 39 tables)

A zirconium-diboride-molybdenum-disilicide solid-solution composition was studied to establish sufficient property data so that this material can be considered for possible future applications.

In the first part of this work an optimum minor addition of boron-nitride powder was determined on the basis of strength (modulus of rupture), oxidation resistance, and thermal shock behavior. Sintering aids, sintering temperature and time, temporary binders, and green-pressing techniques were studied to produce reproducible sintered material.

The second part was a property-testing program at temperatures up to 2000 C (3632 F) which included oxidation resistance to convection and forced air, modulus of rupture, creep strength, modulus of elasticity, thermal expansion, thermal conductivity, thermal shock resistance, and emissivity. Where practical, standard deviations were calculated to yield reproducibility information.

50734 HIGH TEMPERATURE COMPOSITE STRUCTURE. R. M. Davis and C. Milewski, Martin Company, Baltimore, Maryland. ASD TDR 62-418, September, 1962, Contract No. AF 33(616)-7497
(3 references, 111 pages, 95 figures, 17 tables)

Two re-entry heat-shield systems intended for efficient operation with surface temperature in the range of 3000 to 4000 F when adapted to spherical nose-cap shapes were designed, developed, fabricated, tested, and evaluated. The heat shields were of the radiative type, utilizing a foamed aluminum-oxide material in the structural insulation-design concept. Dense facings and resin impregnation were used to alter the basic foam, with the latter proving the better modification as shown by simulated re-entry tests in a large hot-gas facility. Effects of various combinations of plasma-jet enthalpy and heating rates on resin-impregnated ceramic foams were compared. These more closely simulated re-entry conditions for ablative (and semi-ablative) type materials.

50770 REINFORCEMENT OF NICKEL CHROMIUM ALLOYS WITH SAPPHIRE WHISKERS. R. H. Kelsey, Horizons Incorporated, Cleveland, Ohio. Bureau of Naval Weapons, Interim Report No. 1, February 19, 1963, Contract No. NOw 63-0138-c
(4 references, 24 pages, 12 tables)

Strong bonding of iron, nickel, chromium, and 347 stainless steel to pure alumina disks has been shown. The pure metals, in the presence of their naturally-occurring oxides could be bonded without additives; alloys of the same metals required additives for the formation of a strong bond. Small amounts of aluminum metal and/or calcium ion have been found to promote the formation of a bond between 347 stainless steel and alumina, and between 80-nickel 20-chromium alloy and alumina.

Study of the thermodynamics of the system iron-oxygen-alumina indicate that dissolved oxygen may play an important role in the formation of the metal-whisker bond.

50783 HIGH STRENGTH GLASS FIBERS DEVELOPMENT PROGRAM. D. L. Hollinger and H. T. Plant, General Electric Company, Evendale, Ohio. SPN, 4th Bi-Monthly Progress Report, January 20, 1963, Contract No. NOw 61-0641-c (FBM) (20 pages, 8 figures, 2 tables)

Work during this period has demonstrated that the tensile strength of E-glass fibers approaches 1,000,000 psi when measured at liquid-nitrogen temperature (77 K). These same fibers showed strengths averaging 500,000 psi when tested at normal room temperature and humidity. The higher measured strength at low temperature is believed to be the true instantaneous strength of the fiber when chemical reaction with its environment is suppressed.

Composite rings of E-glass monofilament and epoxy resin exhibit the same percentage increase over room-temperature strength when tested at liquid-nitrogen temperature as do the bare fibers from which they are made.

50790 DEVELOPMENT OF COMPOSITE STRUCTURAL MATERIALS FOR HIGH TEMPERATURE APPLICATIONS. W. H. Sutton, J. Chorne', and A. Gatti, General Electric, Cincinnati, Ohio. Bureau of Naval Weapons, Eleventh Progress Report, February, 1963, Contract No. NOw-60-0465-d (7 references, 36 pages, 11 figures, 3 tables)

The purpose of this program is to develop new composite materials for high-strength, structural applications at elevated temperatures. The approach has been that of reinforcing metals with ultra-high-strength single-crystal filaments (whiskers), with emphasis being placed on silver - α - Al_2O_3 (whiskers) composites.

The progress for this period is summarized: (1) The studies on the growth of α - Al_2O_3 whiskers have resulted in substrate materials which will favor growth by a continuous process, and the preliminary design of a continuous process furnace was completed; (2) A marked improvement in the microstructure of the composites has resulted from improved fabrication procedures; (3) A system for fabricating composites by vacuum-pressure infiltration under controlled conditions is being constructed; (4) Several composites were tested at room temperature, and the greatest strength achieved was 232,000 psi in tension for a silver composite containing 24 v/o whiskers; (5) Over thirty metals were considered for future studies on more refractory composites.

50795 THERMAL TRANSPORT AND RADIATIVE PROPERTIES OF FIBROUS STRUCTURAL MATERIALS. G. Engholm, S. J. Lis, and R. J. Baschiere, General American Transportation Corporation, Niles, Illinois. ASD-TDR-62-810, Technical Documentary Report, ASD, November, 1962, Contract No. AF 33(616)-8181 (24 references, 157 pages, 75 figures, 30 tables)

Measurements were made of the thermal conductance and total normal emittance of the following fibrous structural materials: 1N Nylon, 11N Nylon; HT-1 types I, II, and III; Pluton; Glass Fiber Cloth; Aluminized Glass Cloth; Vitreous silica, uncoated, RTV 60 coated, and Parson's Optical Black coated; Graphite cloth; and Rene' 41 cloth, uncoated and CS-105 coated. Data were obtained with a thermal-conductance apparatus and a thermal-emittance apparatus both developed during the program.

50796 See Special Refractories.

50817 ACOUSTICAL ANALYSIS OF FILAMENT-WOUND POLARIS CHAMBERS. A. T. Green, General Tire & Rubber Company, Aerojet-General Corporation, Sacramento, California. Bureau of Naval Research, Report No. 0672-01BM-3, Bi-Monthly Progress Report No. 3, January 25, 1963, Contract No. NOw 62-1007c(FBM) (6 pages, 9 figures)

The objectives of this program are: (i) to develop sound-recording procedures so that the significance of sounds emanating from first-stage Polaris Model A3 chambers during hydrostatic testing may be determined, and (2) to determine experimentally the velocity of sound in a composite material of glass filaments and resin, and the effects that filament-winding direction and superimposed stress fields have on that velocity.

The over-all areas of progress discussed in this report include a tabulation of the test equipment received, data from velocity-of-sound studies, a discussion of the progress made in developing refined instrumentation procedures for hydrostatic testing, and a literature search.

50837 APPLIED RESEARCH TO ESTABLISH INFRARED DETECTION METHODS FOR NONDESTRUCTIVE ANALYSIS OF METALLIC AND CERAMIC STRUCTURES. D. R. Maley, Automation Industries, Inc., Boulder, Colorado. ASD, ASD-TDR-62-385, Technical Documentary Report, January, 1963, Contract No. AF 33(616)-7725 (3 references, 85 pages, 26 figures)

This program was a study to determine the feasibility of thermal nondestructive evaluation of materials. A thermal testing system was conceived and developed with which certain fabricated material inconsistencies have been detected in standard test samples. The system operation is basically a programmed heating and subsequent temperature measurement over one surface of the test sample. Heat flow from the heated surface into the material is examined through the surface temperature measurement. Temperature is measured with an infrared detection system. A display of the temperature pattern over the surface is then interpreted with respect to internal material inconsistencies. A section of the report entitled "Test Results" summarizes the tests, showing the detection of inconsistencies in the standard material samples. Inconsistencies detected to date include voids, delamination (areas of unbonding), and metallic inclusion.